Final Progress Report

for

X-Ray Telescope Experiment

package

( 12 Oct. 1965 - 15 March 1966 )

Contract No. NAS5 - 9690

Prepared by

Speedring Corporation

7111 East Eleven Mile Rd.

Warren, Michigan

for

Goddard Space Flight Center

Greenbelt, Maryland

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## List of Illustrations - Drawings and Tables

# II TECHNICAL DISCUSSION

## II. 1 General Mechanical Description for Aerobee 4.95 x-ray Instrument Package.

When the x-ray instrumentation package is accurately pointed toward the sun, solar radiation incident upon the annular lens * is focused by means of reflection off the inner surface of the annular lens onto the aperture of a camera. The lens consists of two tandem annular conical frustums which are held in optical alignment by a beryllium holder which integrae with the beryllium base plate. To prevent radiation which does not reflect off the annular lens, and hence that radiation which is not properly focused, from exposing the film an entrance aperture stop is inserted. Since the lens consists of two tandem annular conical frustrums, a double image is formed. Consequently, an exit aperture stop is used to control the shape of the inner edge of the image. Prior to entering the camera the radiation passes through an electrically actuated shutter is attached to the face of the camera housing. The two cameras each have eight film stations and are indentical to each other. The mechanism of the camera is accurate enough to insure that the center of the image formed on the film inserted in any respective position in the x-ray camera falls within 0.005 inches of the center of the film. Each successive film position

* The experiment consists of two x-ray telescopes but for purposes of discussion we shall describe only one at the present time.

in a given camera is perpendicular to the optical axis to within 20 seconds of arc. Firmly attached to the camera is an adjustable mount, which in turn is mounted to the base plate. The slide control design provides 0.3 inches free travel and is a positive locking device to securely lock the focal length of the telescope. A vernier scale references the camera with respect to the camera mount. When calibrated, the vernier provides an accurate means of adjusting the optical focal length. The camera is actuated by a clock spring and a clock escapement arm which is actuated via a solenoid-electronic control to allow advancement of the mechanism to the respective film stations. As a resalt of the escapement arm actuation no single station can be missed. The re-entry shutter is designed into a light-tight shield surrounding the beryllium film holder is provided by four screws which hold the light shield in the camera base. The re-entry is a bistable device i.e. it is either pinned in the shutter open or the shutter closed position. Once the re-entry solenoid is energized it must be manually reset by releasing the shutter locking pin and arming the shutter torsion spring. In addition to the two telescopes, two radiation detectors (proportional counters) of the LND type are also mounted on the base plate. These detectors have aperture plates and attached filters, to control the range of the incoming x-rays.

## II. 2 General Electronics Description For Aerobee 4.95 X-Ray Instrument Package

The electronic instrumentation consists of three independent functions:

1. Aluminum window proportional counter.
2. Beryllium window proportional counter.
3. Electronics for activating and monitoring the operation of the camera and shutter mechanisms.

The complete electronics and high voltage supply for the Al counter is housed in a single aluminum case which is to the base plate. Likewise the electronics for the Be counter is housed in a similar case. Each of the counter electronics, camera and shutter control circuits is independent of each other for maximum ultilization of the experiment in the event of a failure. The interface connections from the instrument package to the "F" section are RF isolated by the use of Erie filter pins. All base plate wiring is done with shielded cables. The counter electronics is grounded at the input of the preamplifier stage in each package. This is done because the electronics case is then used as an electrostatic shield surrounding the high sensitivity stages. The electronics are constructed from high reliability components throughout. The electronics operate to specifications under the following environmental conditions:

1. Temperature range -25 degrees C to +125 degrees C.
2. Vibration (3 axis) 10 G mean, 5-500 HZ Random
3. Shock (3 axis) 50 G, 10 times.
4. Acceleration (3 axis) 100 G, 15 minutes.
5. Vacuum - Atmosphere to $10^{-5}$ torr

All semi conductors conform to Mil-S-19500 and Mil-Std-750, or to the Fairchild FACT quality assurance program. All resistors conform to Mil-R-10509D. All capacitators conform to Mil-C-19978B or Mil-C3965B.

Battery power requirements are:

1. To operate each camera mechanism:

   Single 160 Millisec pulse, 17-21V, 0.5 AMP. at 19.5V.

   Current is drawn only during advancement of the camera.

2. To operate each shutter mechanism:

   Continuous requirement of 260 ma. at 19.5V.

3. Electronics for Al-window proportional counter 17-21V, 350 ma.

4. Electronics for Be-window proportional counter 17-21V, 200 ma.

### II. 2.1a Electronics for the Aluminum-Window Proportional Counter

A block diagram of the electronics is shown in Fig 1.

See the Appendix for detailed circuit schematics.

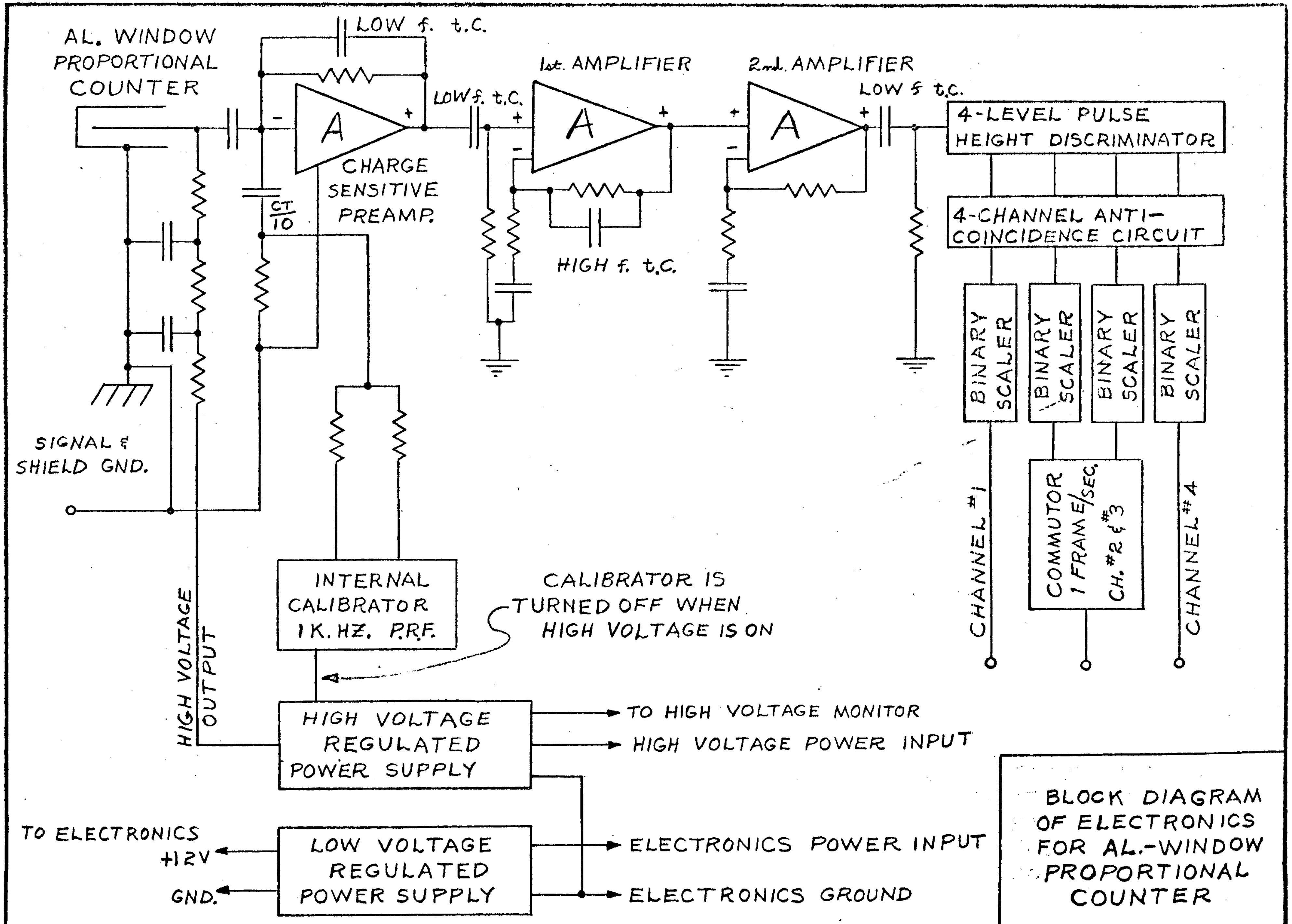
The circuit is conventional, consisting of:

1. A charge sensitive preamplifier
2. A main amplifier
3. A 4-level discriminator following by anti-coincedence circuits to provide a 4-channel differential pulse height analysis and
4. $2^7$ bit binary scalers for each discriminator channel. For each scaler, the 3 most significant bits are sensed to give an 8-level analog readout to telemetry.
5. A 0.1% regulated, +1600 to +2300V high voltage supply for the proportional counter chamber.
6. A +12V regulated supply for the counter electronics.

The principle operating characteristics of the unit are set out in Table I, Fig 2.

### II. 2.1b Description of Operation

Refer to the block diagram in Fig 1 to follow the circuit philosophy. The proportional counter tube is a device for producing a multiplication of incoming photons. The AL window has a pass band that allows (photon radiation) between 8-20Å to enter the proportional counter tube. When the high voltage applied to the counter tube is precisely controlled, the multiplication and production of secondary ion pairs is accurately determinable. The ion pair generation




BLOCK DIAGRAM OF ELECTRONICS FOR AL.-WINDOW PROPORTIONAL COUNTER

FIG.-I

can be looked upon as a true generation of charge because the input of the preamplifier is largely capacitance. The input capacitance is determined by the open loop gain and the transition or feedback capacitance. The input capacitance is approximately.

$C\ in = A_{vo}\ C_t$, where $A_{vo}$ = open loop gain, and $C_t$ is the transition capacitance.

The output of the preamplifier is a low source impedance voltage whose amplitude depends only on the transition capacitance, the impinging x-ray flux energy, and the high voltage applied to the counter tube. The preamplifer output is then amplified and shaped by RC time constants to result in a narrow gaussian band-width with a center frequency near 500 KHZ. Two non-inverting amplifiers are used and their gains adjusted (by the choice of feedback resistances) so that the input for a 8Å x-ray flux or $8.8 \times 10^5$ ion pairs produces an output of 3.05 volts. This amplifier output is then fed to a height analyzer which has four channels which lead to ripple counters and scaler circuits. In the height analyzer, micrologic circuits are used throughout to increase reliability and save space. Operation is straight forward in that the input pulse level to the analyzer is compared to a voltage divider which determines to which channel that pulse should add its count. In the process each of the lower channel multivibrators are triggered but the anti-coincidence logic prevents the lower energy channel counters from receiving these counts. The outputs from channels 2 and 3 are commutated at a 1 frame / sec rate while channels 1 and 4 are fed to telemetry outputs directly.

Table I  Fig II

PERFORMANCE SPECIFICATIONS OF THE ELECTRONICS FOR THE ALUMINUM WINDOW PROPORTIONAL COUNTER

1. Channel Heights

| | Channel heights in terms of ion-pairs referred to the preamplifier input | Channel heights in terms of the wavelength of the incident X-Ray quantum (assuming a 20 Angstrom unit quantum produces 3.5 x $10^5$ ion-pairs). |
|---|---|---|
| Channel I | 8.8 x $10^5$ | 8 Angstrom unit |
| Channel II | 5.8 - 8.8 x $10^5$ | 12-8 Angstrom unit |
| Channel III | 4.4 - 5.8 x $10^5$ | 16-12 Angstrom unit |
| Channel IV | 3.5 - 4.4 x $10^5$ | 20-15 Angstrom unit |

| | |
|---|---|
| 2. System Linearity | Better than 1% |
| 3. Channel Height Stability | |
| Long term and temperature (-25) degrees C to +125 degrees C) drift | $\pm$4% or $\pm$ 1500 ion-pairs referred to the input, whichever is the greater |
| Relative long term and temperature (-25 degrees C to +125 degrees C) drift between channels | $\pm$1500 ion pairs referred to the input. |
| 4. RMS Input Noise Level | 1500 ion-pairs at -25 degrees C<br>1500 ion-pairs at 25 degrees C<br>2500 ion-pairs at 125 degrees C |
| 5. Feedback Input Capacitance of the Charge Sensitivity Preamplifier | Greater than 500 pf. |

6. Channel Height Variation with change in the capacitance of the Proportional Counter — -0.2% per 1 pf

7. Pulse Shaping

   The pulse is shaped by single high-frequency time constant at 0.51 μsec and a triple low-frequency time constant at 10μ sec, 0.795 μsec, and .74 μsec.

8. Recovery Times

   Taking the mean pulse height (MPH) as $5 \times 10^5$ ion-pairs at the input;

   Recovery time from an overload of 100 x MPH to 1% of MPH — 8 μsec.

   Recovery time from a pulse to 1 x MPH to 1% of MPH — 5 μsec.

   Probability of a 1% error in measured pulse height at a mean pulse repetition frequency (MPHF) of 2000 sec-1. — 1%

   Probability of a missed count at a MPHF of 2000 sec-1 — 0.3%

9. Base Line Shift with Pulse Repetition Frequency — Nil.

10. Maximum Counting Rate of $2^7$ bit Binary Sealers — 5 Mc

Fig II, continued

11. High Voltage Supply to Proportional Counter

| | |
|---|---|
| Adjustment range | 1600 to 2300V |
| Long term and temperature stability (-25 degrees C to 100 degrees C) | 0.1% |

12. DC Battery Power Required — +17 to +21V, 350 ma

An output from the ripple counter and scaler characteristically has 8 levels including the zero level. The number of input counts per step is 16 and the total number of counts per staircase is 128. The commutated outputs of channels 2 and 3 are distinguishable by a 2/3 ratio in their volts per step.

The high voltage supply is conventional in concept, but sophisicated in its refinements. The circuitry consists of a series regulator control to supply a source for the Dc/Dc transformation. The chopper is a non-saturating 20 KHZ free running multivibrator driving a pair of low saturation switches. The voltage is then stepped up and rectified by a half-wave voltage doubler and filtered by a three section-pi to reduce ripple to 2 microvolts. In the d-c output circuit, a highly stable voltage divider consists of 20-1 meg metal film resistors. A fraction of the divider voltage is compared to the reference which is a low current planar zerner diode. The regulator amplifier has a 3db frequency response of 500 HZ. An accessory provided is a high voltage monitor which gives an indication of the performance of the regulator. A FET used as a source follower monitors an internal point in the regulator and the voltage measured at that point indicates that the regulator is functioning. Since the regulator has a high d-c gain the voltage at the monitor will be either zero or 5 volts if there is a high voltage malfunction. The long term stability of the supply is better than 0.1% and the voltage is adjustable from 1600 to 2300 volts by means of a precision potentionmeter.

The 12 volts dc regulated supply is a conventional series regulator. It supplies the high voltage oscillator regulator power and all power required by the counter electronics. The accuracy of the supply is better than ± 1% over the required temperature range, giving a more than adequate reference for the pulse height level discriminator circuits. The input to the electronics through the regulator can range between 15V and 25V with a line regulation of less than 10 mv. The current required is less than 350 ma.

### II. 2.2a Electronics for the Beryllium-Window Proportional Counter

A block diagram of the electronics is shown in Fig III.

See the Appendix for detailed circuit schematics.

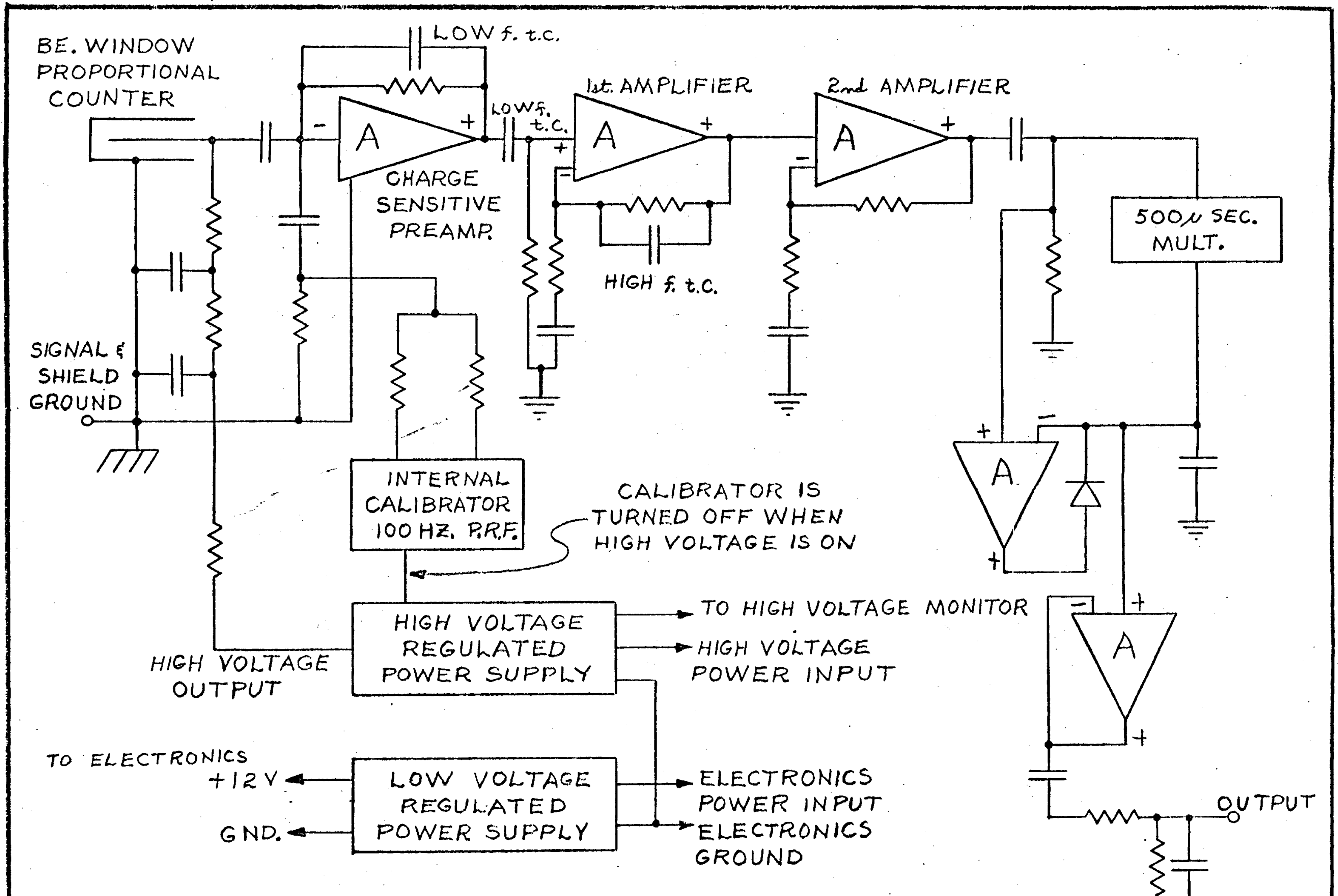
The circuit consists of:

1. A charge - sensitive preamplifier
2. A main amplifier
3. A pulse stretching system
4. A 0.1% regulated, 1600 to 2300 V high voltage supply for the proportional counter (described under section 1b)
5. A + 12V regulated supply for the counter electronics (also described under section 1b)

The principle operating characteristics of the unit are set out in Table II, Fig. IV.

### II. 2.2b Description of Operation

Refer to the block diagram in Fig III to follow the circuit philosophy. The proportional counter tube is a device for producing a multiplication of incoming photons. The Be window has a passband that allows photon radiation between 1-8Å to enter the proportional counter tube. The multiplication and production of secondary ion pairs is accurately determinable (when the high voltage applied to the counter tube is precisely controlled). This ion pair generation can be looked upon as a true generation of charge because the input of the preamplifier is largely capacitance. This capacitance is determined by the open loop gain and the transition or feedback capacitance.




BLOCK DIAGRAM OF ELECTRONICS FOR BE.-WINDOW PROPORTIONAL COUNTER

FIG. III

Table II, Fig. IV

## Performance Specifications of the Electronics for the Beryllium Window Proportional Counter

| | | |
|---|---|---|
| 1. | Gain (output to telemetry from input to preamplifier) | $1.28 v/10^6$ ion pairs |
| 2. | System Linearity | $\pm 2\%$ |
| 3. | Gain Stability Long term and temperative (-25 degrees C to +125 degrees C) drift | $\pm 4\%$ |
| 4. | Maximum Signal Amplitude | |
| | At input to preamplifier | $3.5 \times 10^6$ ion-pairs |
| | At output to telemetry | 4.5V |
| 5. | Input Capacitance for the Change-Sensitivity Preamplifier | greater than 500 pf |
| 6. | Gain Variation with change in the capacitance of the Proportional Counter | -0.2% per 1pf |
| 7. | RMS Input Noise Level | 2500 ion-pairs at -25 degrees C<br>2500 ion-pairs at 25 degrees C<br>9000 ion-pairs at 125 degrees C |
| 8. | Shape of Stretched Pulse | |
| | Pulse elevation | 500 $\mu$sec $\pm$ 2% |
| | Rise and fall times | 50 $\mu$sec $\pm$ 2% |
| | Sag during pulse | 5% |
| | Fraction of peak amplitude reached at end of 500 $\mu$sec. | 0.95 |

| | |
|---|---|
| 9. **Recovery** | |
| Recovery time (from the termination of the stretched pulse) for a pulse of 1 x mean pulse height (MPH) to 5% of MPH. | 450 $\mu$ sec. |
| Probability of a 5% shift in pulse height (strictly in base line) at a mean pulse repetition frequency (MPRF) of 200 sec - 1 | 10% |
| Probability of a second pulse during the stretching of a first pulse at a MPRF of 200 sec - 1 | 10% |
| 10. **High Voltage Supply to Proportional Counter** | |
| Adjustment range (by external trimming resistor) | +1600 to +2300V |
| Long term and temperature stability (-25 degrees C to 100 degrees C) | 0.1% |
| 11. **DC Battery Power Requirements** | +15 to +21V, 200 mA max. |

The output of the preamplifier is a low source impedance voltage whose amplitude depends only on the transition capacitance, the impinging x-ray flux energy, and the high voltage applied to the counter tube. The preamplifier output is then amplified and shaped by RC time constants which results in a narrow gaussian bandwidth with a center frequency near 50 KHZ. Two non-inverting amplifiers are used and their gains adjusted (by the choice of feedback resistances) so that the input for a 1 Å x-ray flux or 3.5 X $10^6$ ion pairs produces an output of 4.5 volts.

This amplifier output is then fed to the pulse stretcher circuitry which produces a pulse of 500 $\mu$ sec duration and whose amplitude corresponds to the peak voltage of the input voltage.

The operation of the circuit is as follows: The charge on the pulse storage capacitor is zero until an input pulse to the pulse stretcher circuit exceeds the threshold voltage level of the multivibrator. Current is then allowed to flow through the pulse storage capacitor from the high gain operational amplifier until the voltage across the capacitor is the same as the peak input pulse. A diode in the feedbackpath prevents the capacitor from discharging as the input pulse diminishes. However, after 500 $\mu$ secs the multivibrator discharges the capacitor and a new cycle may begin.

A second operational amplifer connected as a perfect voltage follower samples the voltage across the pulse storage capacitor without causing any significant droop in the stretched pulse. Finally, the pulse is shaped by RC time constants to give the specified rise and fall characteristics and then fed to elemetry.

## II. 2.3a Camera Electronics and Shutter Control

A block diagram for the camera electronics is shown in Fig V. See the Appendix for the detailed circuit schematic.

The circuit consists of:

1. Two independent camera solenoid circuits.
2. Shutter motors for controlling film exposure time.
3. Re-entry solenoids operating one-time camera shutters.
4. A resistor matrix to sum voltages from the shutter motors and camera wheel switches. The operation of the entire circuit is monitored at this point.

## II. 2.3b Description of Operation

In the block diagram only one camera channel is described because the 2nd camera channel is identical. The shutter command is shown as a switch because the function performed in the "F" section timer accomplishes that simple act.

To examine the function of the circuit assume the shutter switch is open and the power is off. Turning the power on, no voltage will appear across the camera solenoid, since the time constant $C_2$ $R_2$ 11 $R_3$ is greater than $R_1$ $C_1$. This arrangement assures that no camera actuation can occur due to turn on transients. Initially the exposure shutter is closed, and $C_1$ is charged to 19.5 volts. On command, the shutter opens for the required exposure time, and $C_1$ discharges through $R_1$. After the exposure, the shutter closes and a pulse generated by the recharging of C through R is amplified and applied to the index solenoid. The time constant is adjusted so that the solenoid energizing pulse is 200 milliseconds long.

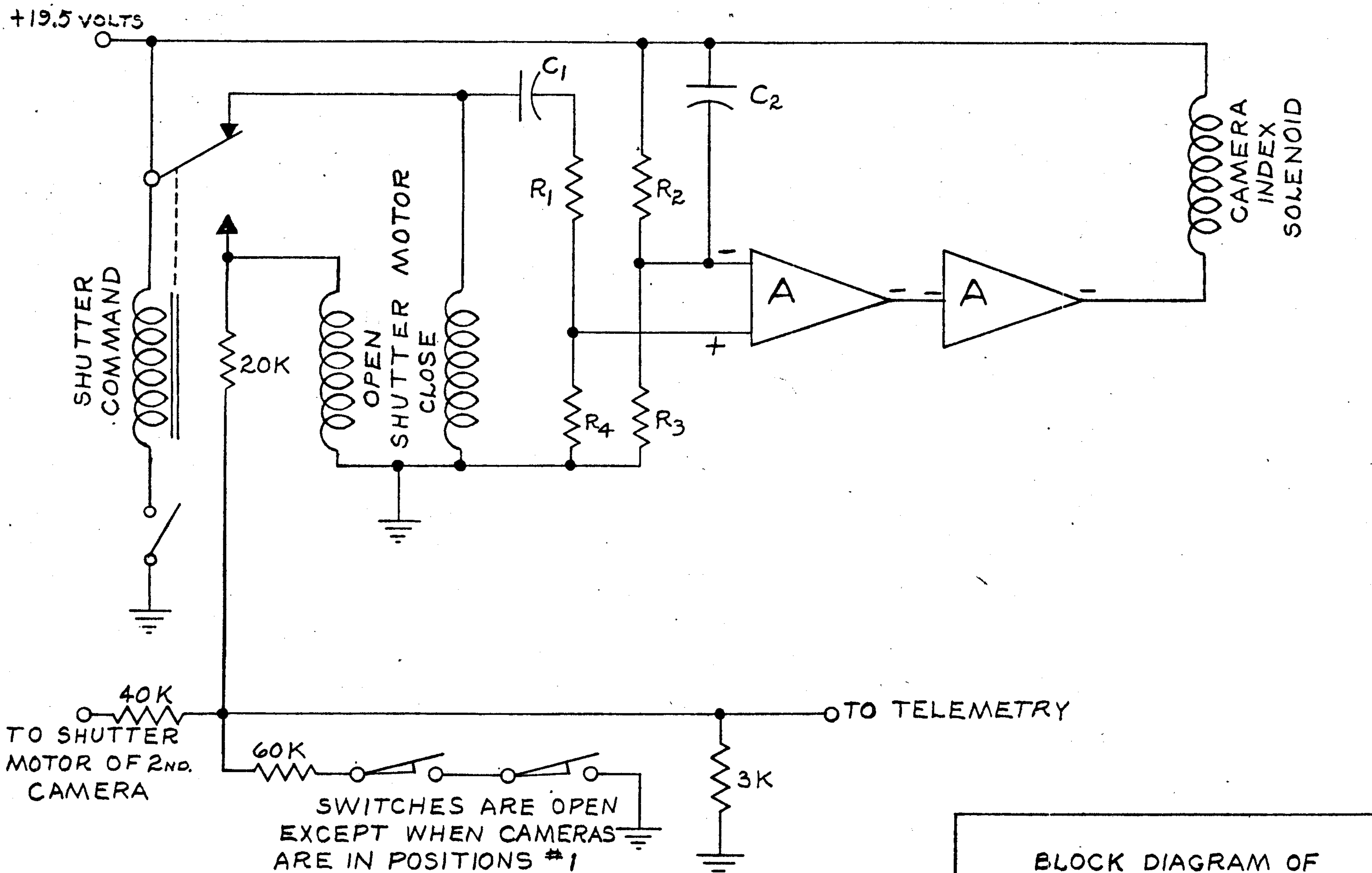



FIG.-V

BLOCK DIAGRAM OF
CAMERA ELECTRONICS
& SHUTTER CONTROL

The re-entry solenoids are double coil types so that little power is required after pull-in. The command for re-entry safety shutter occurs after all the pictures have been taken and the total experiment is over.

## III Performance During Pre-flight Tests and During Flight

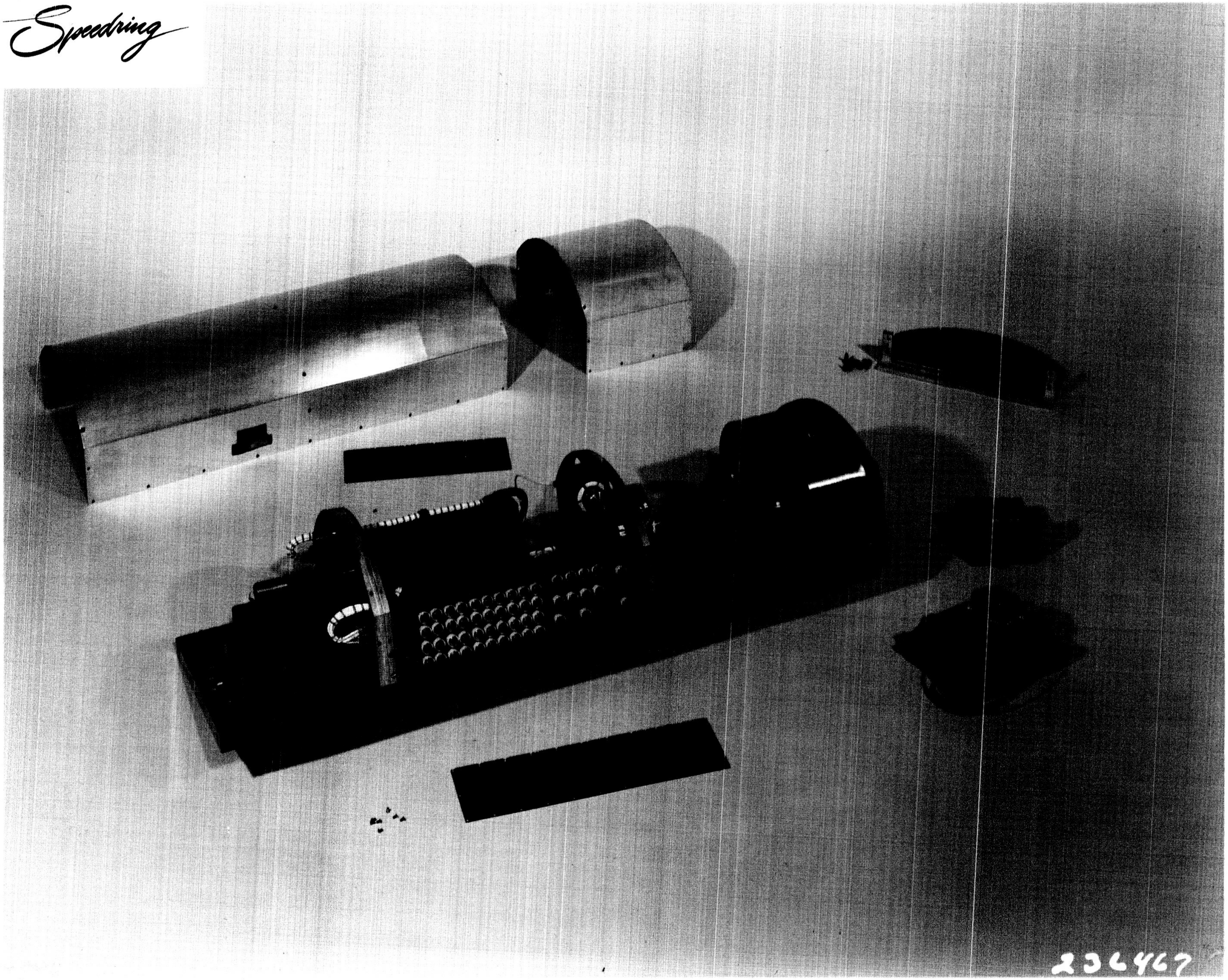
The x-ray telescope experiment package was delivered to Dr. J. H. Underwood on March 10, 1966 and was formally accepted on March 31, 1966.

The acceptability tests included temperature cycling, operation through the corona region and through vacuum, and a vigorous mechanical shake. Field devices by a Speedring engineer were provided during these acceptability tests.

Integration of the instrument with the pointing control occured at Ball Brothers Research Corp. in Boulder, Colorado April 25 through May 6. A mechanical and an electrical engineer from Speedring provided field support services.

Field support was continued at White Sands, New Mexico May 9 through May 20. The "horizontal" "vertical", and "flight ready" performances were run without incident. During the actual flight again no problems occured and all systems performed as desired. After recovery, examination showed that the only visible damage was to the cover of the instrument. The success of the experiment was really determined when the cameras were found to have taken 16 well focused and scientifically exciting x-ray photographs.

# APPENDIX


Speedring
236467

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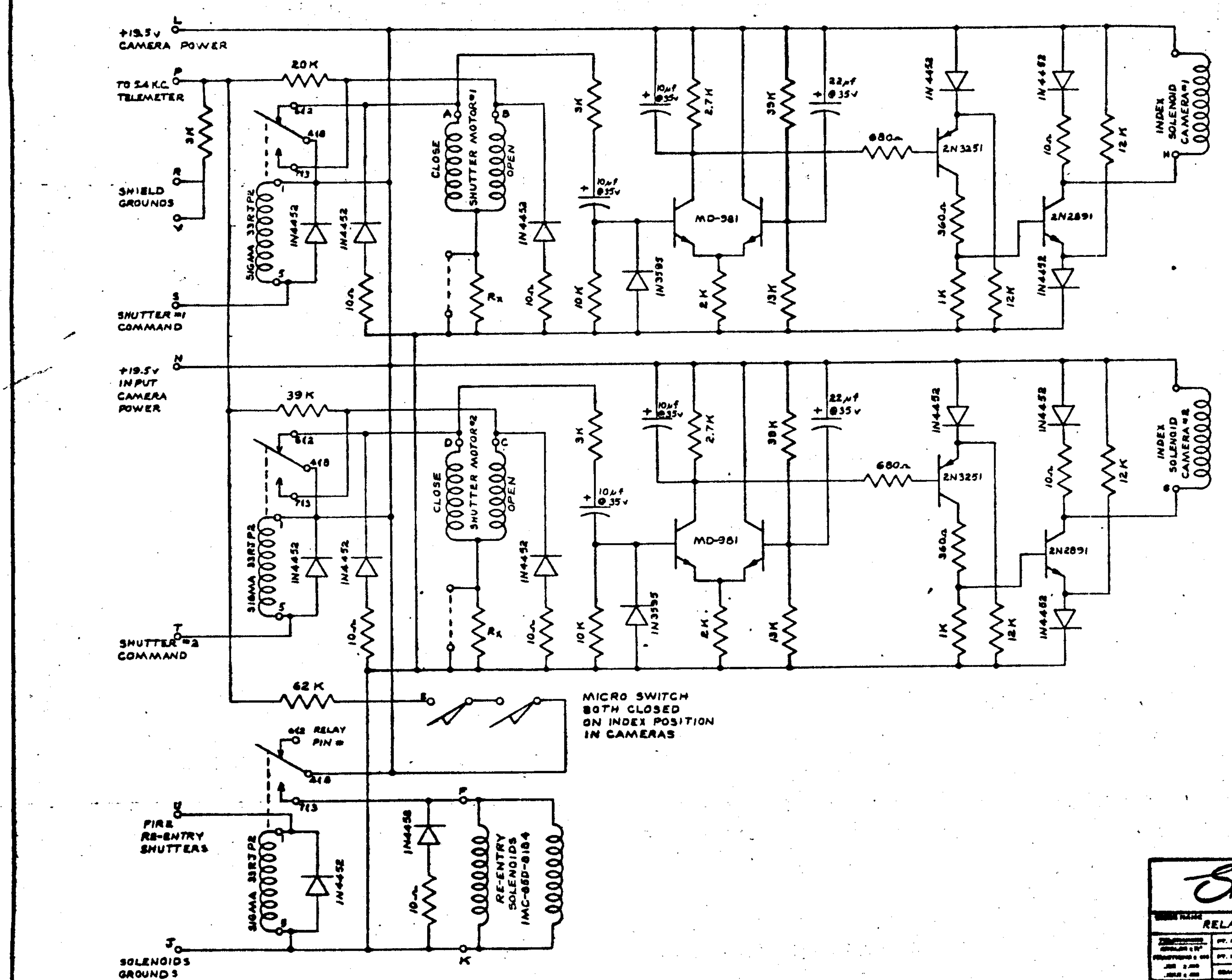
| Copy (22,23,24,25) | Speedring Corporation, Warren, Michigan | |




$R_x$ IS A SERIES DROPPING RESISTORS IF REQUIRED

| TABLE OF OUTPUT CONNECTORS | | |
|---|---|---|
| POINT | PIN # | CONNECTOR # |
| A | 1 | $P_5$ |
| B | 2 | $P_5$ |
| C | 4 | $P_5$ |
| D | 5 | $P_5$ |
| E | 14 | $P_5$ |
| F | 7 | $P_5$ |
| G | 10 | $P_5$ |
| H | 9 | $P_5$ |
| J | 6 | $P_4$ |
| K | 12 | $P_5$ |
| L | 1 | $P_4$ |
| N | 11 | $P_5$ |
| P | 9 | $P_4$ |
| R | 13 | $P_5$ |
| S | 3 | $P_6$ |
| T | 5 | $P_6$ |
| U | 7 | $P_4$ |
| V | 8 | $P_4$ |

REF. TO DRAWING B-5311 & B-5309

Sparling Corporation
WARREN, MICHIGAN

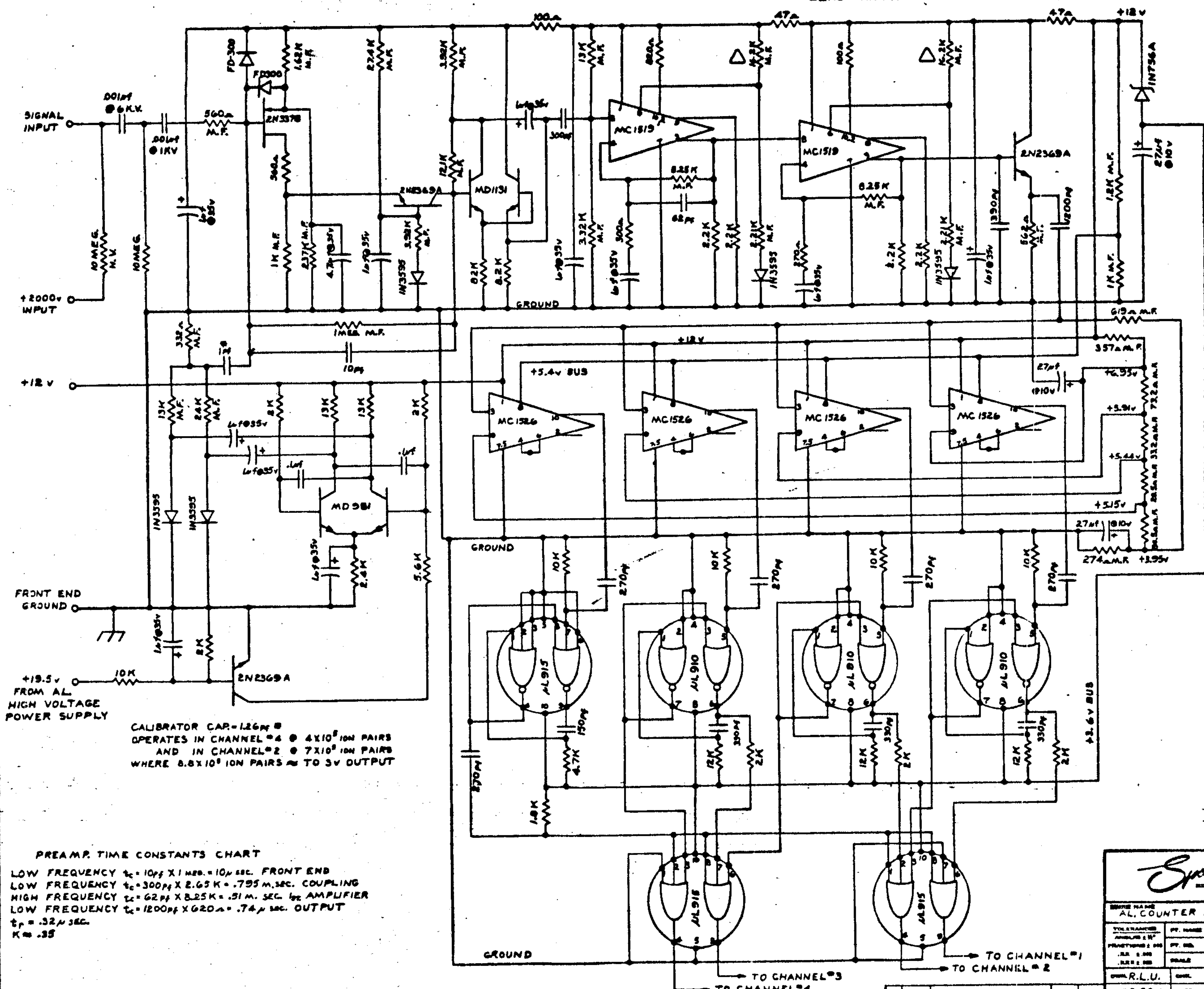
RELAY CONTROL ELECTRONICS

DRN. R.L.U.

DATE 3-18-66

C-5308

△ ADJUST RESISTANCE VALUE FOR ZERO TEMPATURE COMPENSATION @ 25°C




CALIBRATOR CAP. = 1.26pf @
OPERATES IN CHANNEL #4 @ 4X10⁶ ION PAIRS
AND IN CHANNEL #2 @ 7X10⁶ ION PAIRS
WHERE 8.8X10⁶ ION PAIRS ≈ TO 3v OUTPUT

PREAMP. TIME CONSTANTS CHART

LOW FREQUENCY $t_c$ = 10pf X 1 MEG. = 10μ sec. FRONT END
LOW FREQUENCY $t_c$ = 300pf X 2.65 K = .795 m.sec. COUPLING
HIGH FREQUENCY $t_c$ = 62pf X 8.25K = .51 m. SEC. 1st AMPLIFIER
LOW FREQUENCY $t_c$ = 1200pf X 620Ω = .74μ sec. OUTPUT
$t_r$ = .32μ sec.
K ≈ .35

NOTE: M.F. INDICATES 1% METAL-FILM RESISTORS

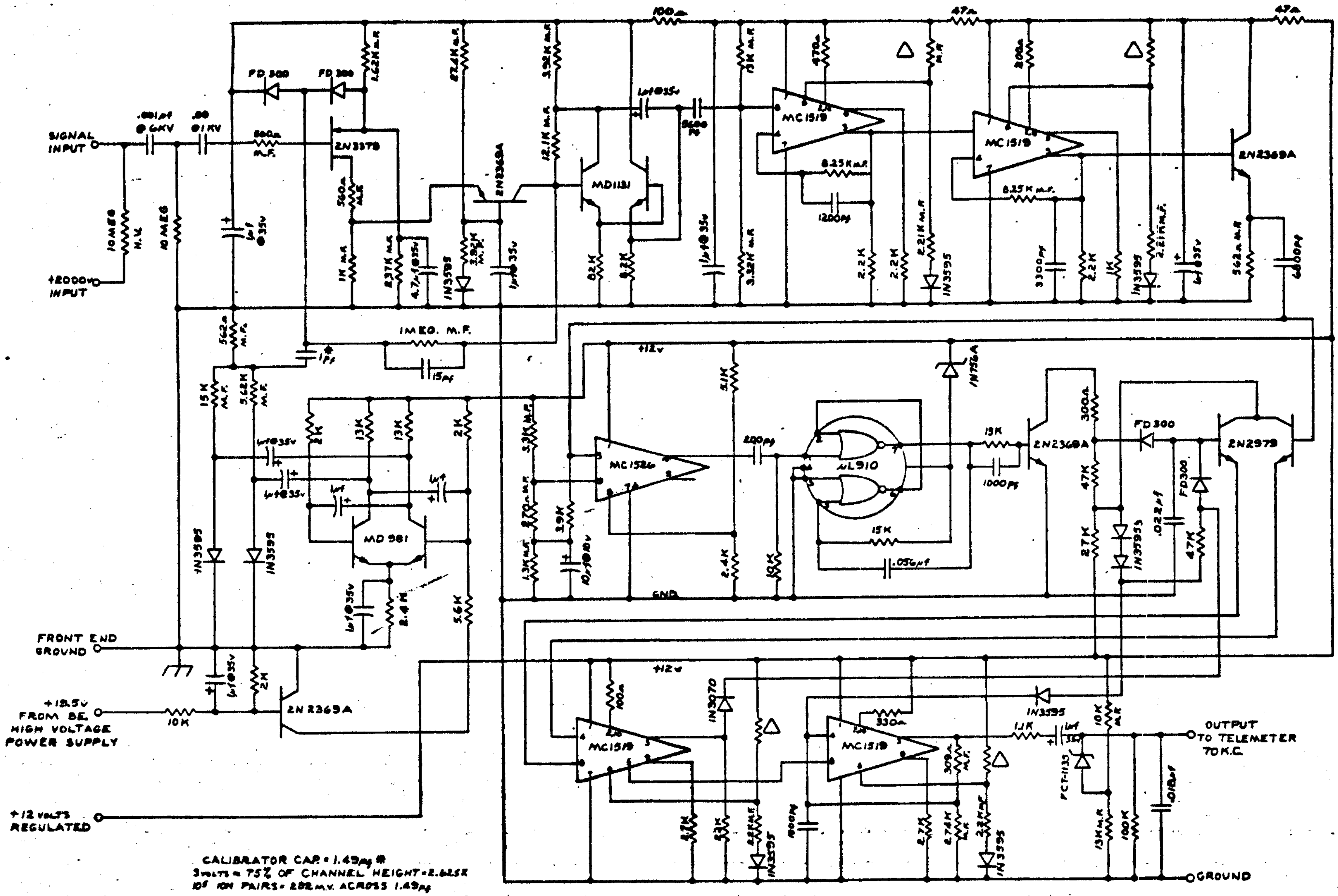
DWG. #1 OF 2

Sparling Corporation
WARREN, MICHIGAN

AL. COUNTER SCALERS & CALIBRATOR

DWN. R.L.U.
DATE 3-23-66
C-5307

△ ADJUST RESISANCE VALUE FOR ZERO TEMPATURE COMPENSATION @ 25°C.




CALIBRATOR CAP = 1.49pf ±
3 VOLTS = 75% OF CHANNEL HEIGHT = 2.625K
10⁵ ION PAIRS = 282 m.v. ACROSS 1.49pf

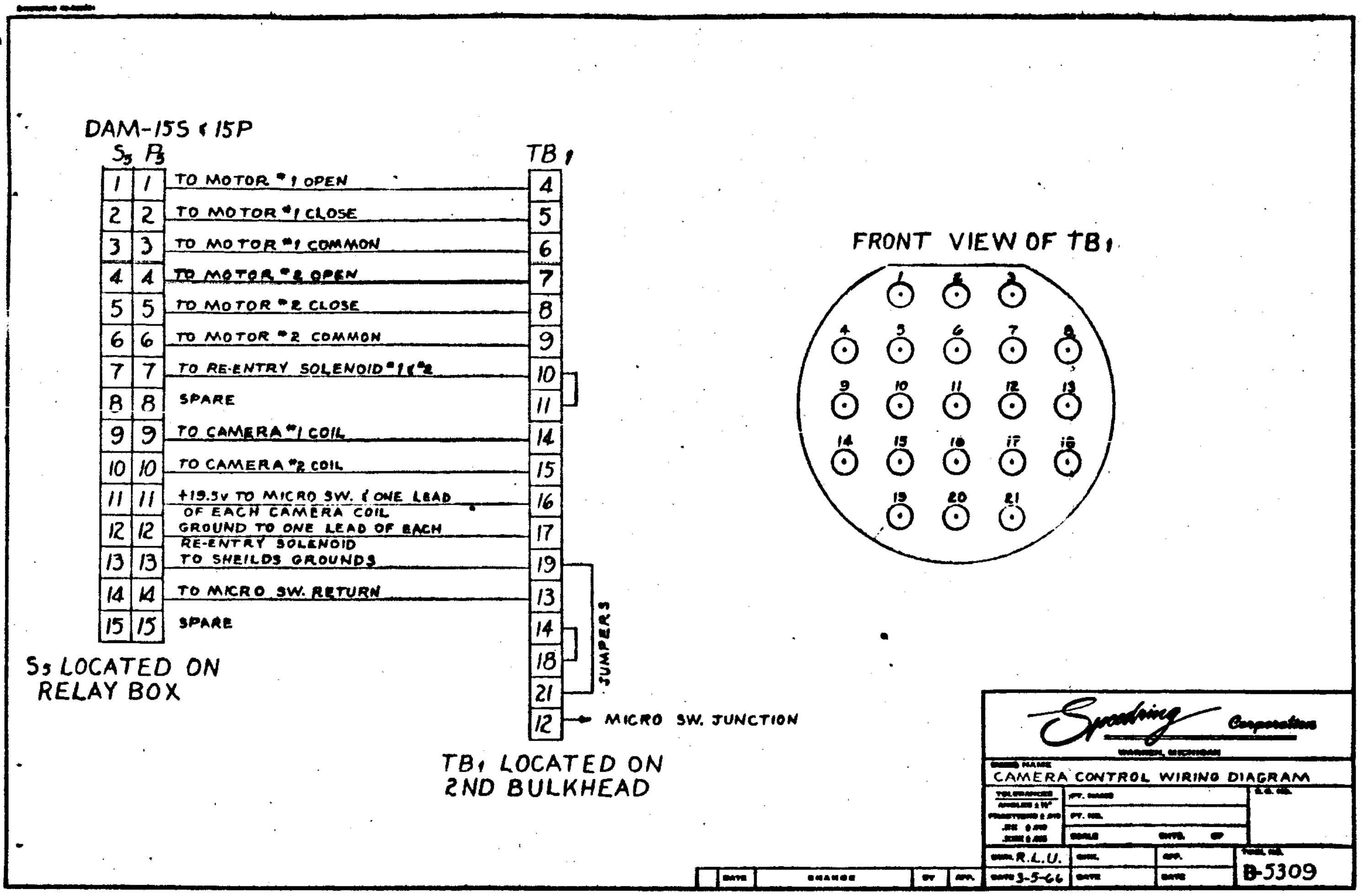
1.2 VOLTS = 25% OF CHANNEL HEIGHT = 94 m.v. ACROSS 1.49pf

PREAMP. TIME CONSTANTS CHART
LOW FREQUENCY $t_c$ = 15pf X IMEG. = 15µsec. FRONT END
LOW FREQUENCY $t_c$ = 5600pf X 2.65K = 15µ sec. COUPLING
HIGH FREQUENCY $t_c$ = 1200pf X 8.25K = 10µ sec. AMPLIFIER
LOW FREQUENCY $t_c$ = 6800pf X 3K = 20.4µ sec. OUTPUT
$t_p$ = 4.38µ sec.
K = .158

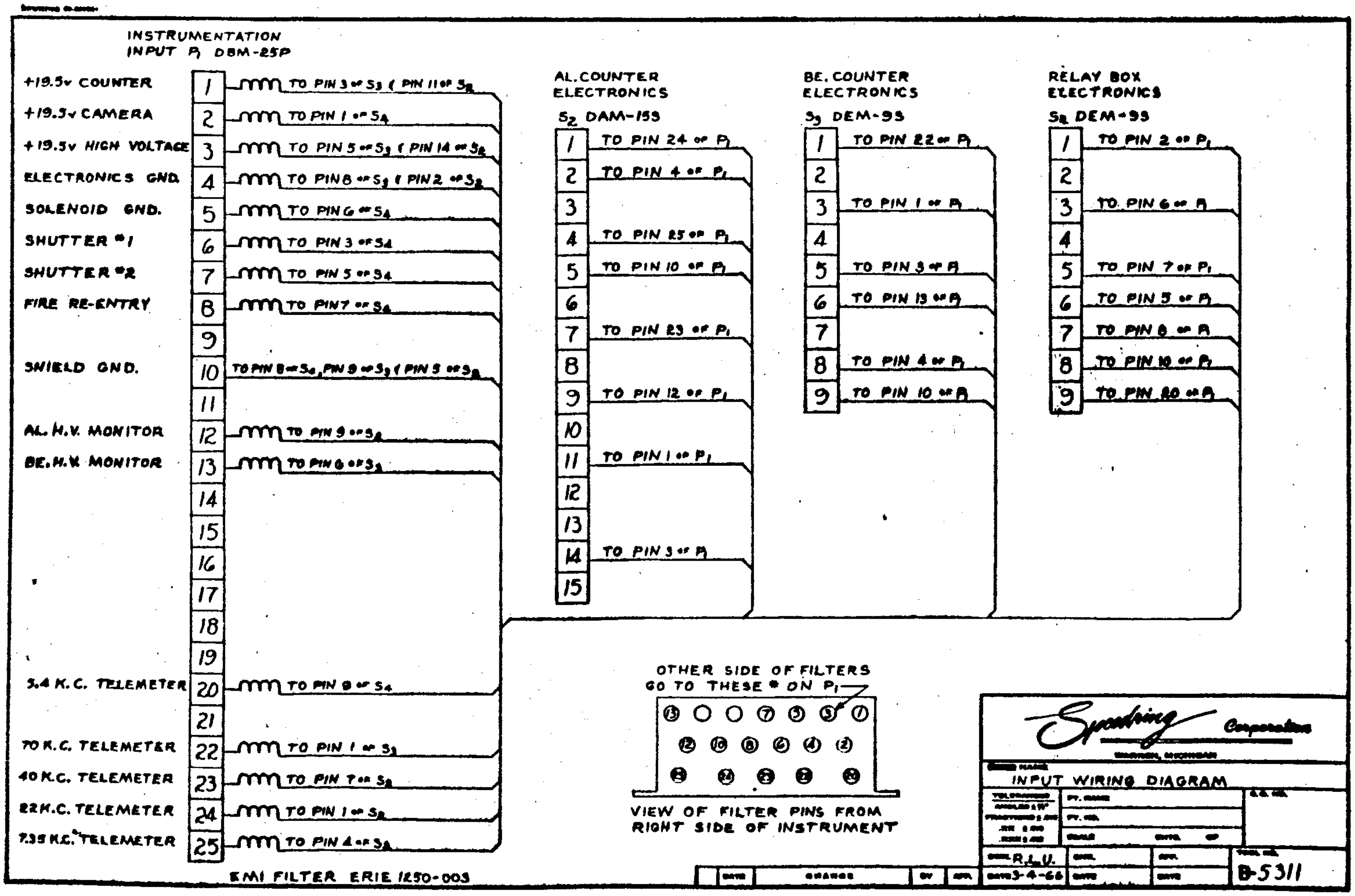
NOTE: M.F. INDICATES 1% METAL-FILM RESISTORS

Spradling Corporation
WARREN, MICHIGAN

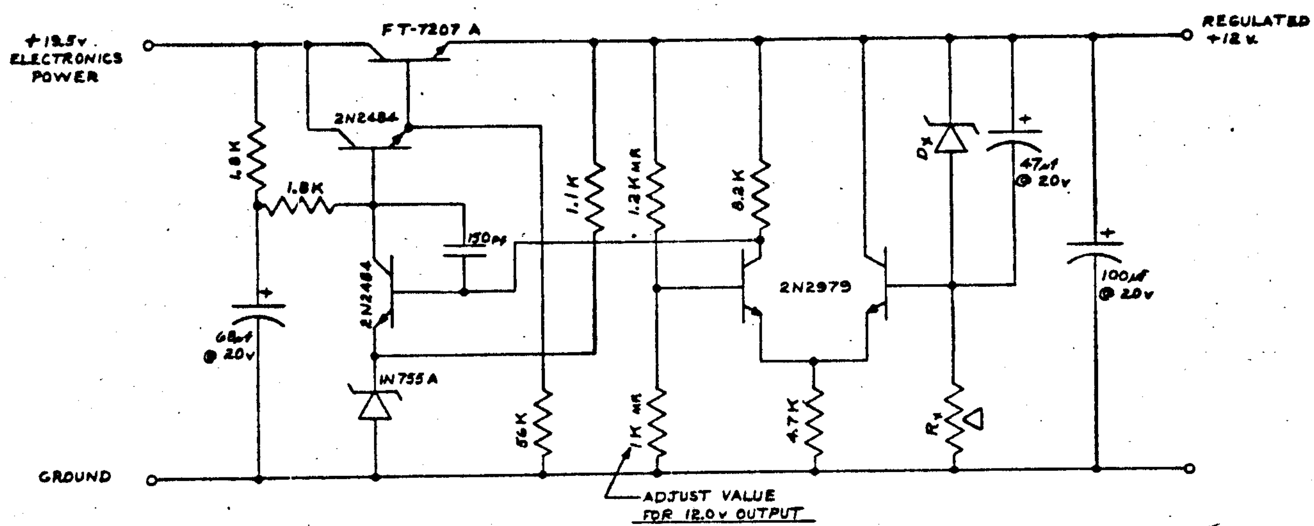
| | |
|---|---|
| NAME | BE COUNTER SCHEMATIC |
| DRAWN | R.L.U. |
| DATE | 3-28-66 |
| DWG. NO. | C-5305 |



DAM-15S & 15P
S3 P3
TB1
TO MOTOR #1 OPEN
TO MOTOR #1 CLOSE
TO MOTOR #1 COMMON
TO MOTOR #2 OPEN
TO MOTOR #2 CLOSE
TO MOTOR #2 COMMON
TO RE-ENTRY SOLENOID #1 & #2
SPARE
TO CAMERA #1 COIL
TO CAMERA #2 COIL
+19.5v TO MICRO SW. & ONE LEAD OF EACH CAMERA COIL
GROUND TO ONE LEAD OF EACH RE-ENTRY SOLENOID
TO SHEILDS GROUNDS
TO MICRO SW. RETURN
SPARE
JUMPERS
MICRO SW. JUNCTION
S3 LOCATED ON RELAY BOX
TB1 LOCATED ON 2ND BULKHEAD
FRONT VIEW OF TB1
Spalding Corporation
CAMERA CONTROL WIRING DIAGRAM
R.L.U.
3-5-66
B-5309

INSTRUMENTATION INPUT P1 DBM-25P
+19.5v COUNTER
+19.5v CAMERA
+19.5v HIGH VOLTAGE
ELECTRONICS GND.
SOLENOID GND.
SHUTTER #1
SHUTTER #2
FIRE RE-ENTRY
SHIELD GND.
AL. H.V. MONITOR
BE. H.V. MONITOR
5.4 K.C. TELEMETER
70 K.C. TELEMETER
40 K.C. TELEMETER
22 K.C. TELEMETER
7.35 K.C. TELEMETER
TO PIN 3 of S3 & PIN 11 of S2
TO PIN 1 of S4
TO PIN 5 of S3 & PIN 14 of S2
TO PIN 8 of S3 & PIN 2 of S2
TO PIN 6 of S4
TO PIN 3 of S4
TO PIN 5 of S4
TO PIN 7 of S4
TO PIN 8 of S4, PIN 9 of S3 & PIN 5 of S2
TO PIN 9 of S2
TO PIN 6 of S3
TO PIN 9 of S4
TO PIN 1 of S3
TO PIN 7 of S2
TO PIN 1 of S2
TO PIN 4 of S2
AL. COUNTER ELECTRONICS
S2 DAM-15S
TO PIN 24 of P1
TO PIN 4 of P1
TO PIN 25 of P1
TO PIN 10 of P1
TO PIN 23 of P1
TO PIN 12 of P1
TO PIN 1 of P1
TO PIN 3 of P1
BE. COUNTER ELECTRONICS
S3 DEM-9S
TO PIN 22 of P1
TO PIN 1 of P1
TO PIN 3 of P1
TO PIN 13 of P1
TO PIN 4 of P1
TO PIN 10 of P1
RELAY BOX ELECTRONICS
S4 DEM-9S
TO PIN 2 of P1
TO PIN 6 of P1
TO PIN 7 of P1
TO PIN 5 of P1
TO PIN 8 of P1
TO PIN 10 of P1
TO PIN 20 of P1
OTHER SIDE OF FILTERS GO TO THESE # ON P1
VIEW OF FILTER PINS FROM RIGHT SIDE OF INSTRUMENT
EMI FILTER ERIE 1250-003
Spalding Corporation
INPUT WIRING DIAGRAM
R.L.U.
3-4-66
B-5311




| TYPE OF ZENER USED | VALUE OF $R_x$ |
|---|---|
| MCR-2035 | 470Ω |
| MCR-2235 | 2.2KΩ |
| IN4573A | 5.6KΩ |

NOTE: MF. INDICATES 1% METAL-FILM RESISTORS

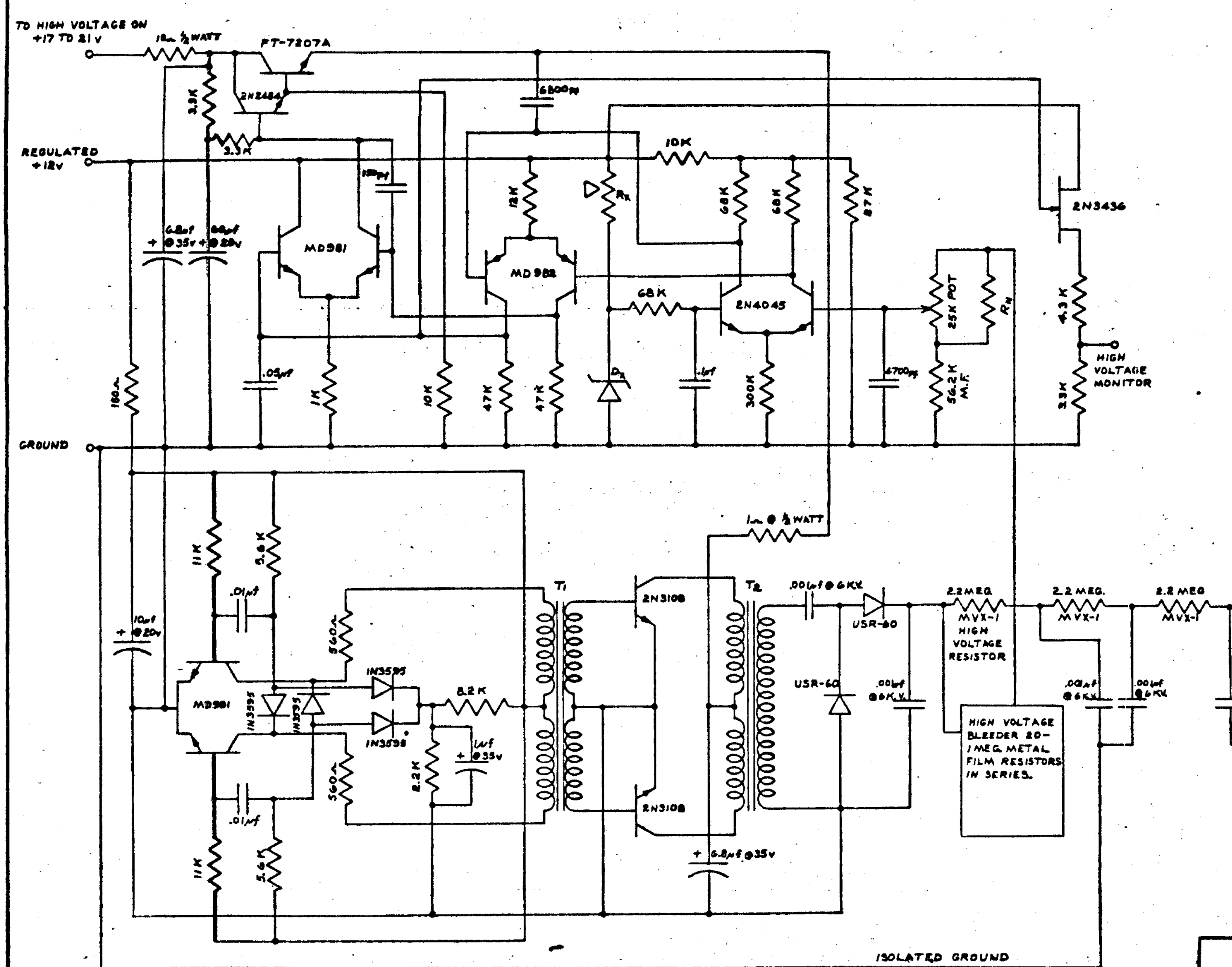
| DATE | CHANGE | BY | APP. |
|---|---|---|---|

Speedring Corporation
WARREN, MICHIGAN

BE. & AL. COUNTERS LOW VOLTAGE SUPPLY

DR. R.L.U.
DATE 3-16-66

TOOL NO. B-5312




| TRANSFORMER DATA |
|---|
| $T_1$ |
| PRIMARY: 232 TURNS BIFILLIAR WOUND WITH #38 DOUBLE FORMVAR WIRE. |
| SECONDARY: 32 TURNS BIFILLIAR WOUND WITH #24 DOUBLE FORMVAR WIRE. |
| CORE: G-L ELECTRIC, TORROID A 1008-MIEE |
| $T_2$ |
| PRIMARY: 29 TURNS BIFILLIAR WOUND WITH #36 SINGLE FORMVAR WIRE. |
| SECONDARY: 2700 TURNS OF #41 SINGLE FORMVAR WIRE. |
| CORE: FERROXCUBE, FERRITE CUP 2616P-L00-3B8 |

| TYPE OF ZENER USED $D_X$ | VALUE OF $R_X$ |
|---|---|
| MCR-2035 | 470 Ω |
| MCR-2235 | 2.2 KΩ |
| IN4573A | 5.6 KΩ |

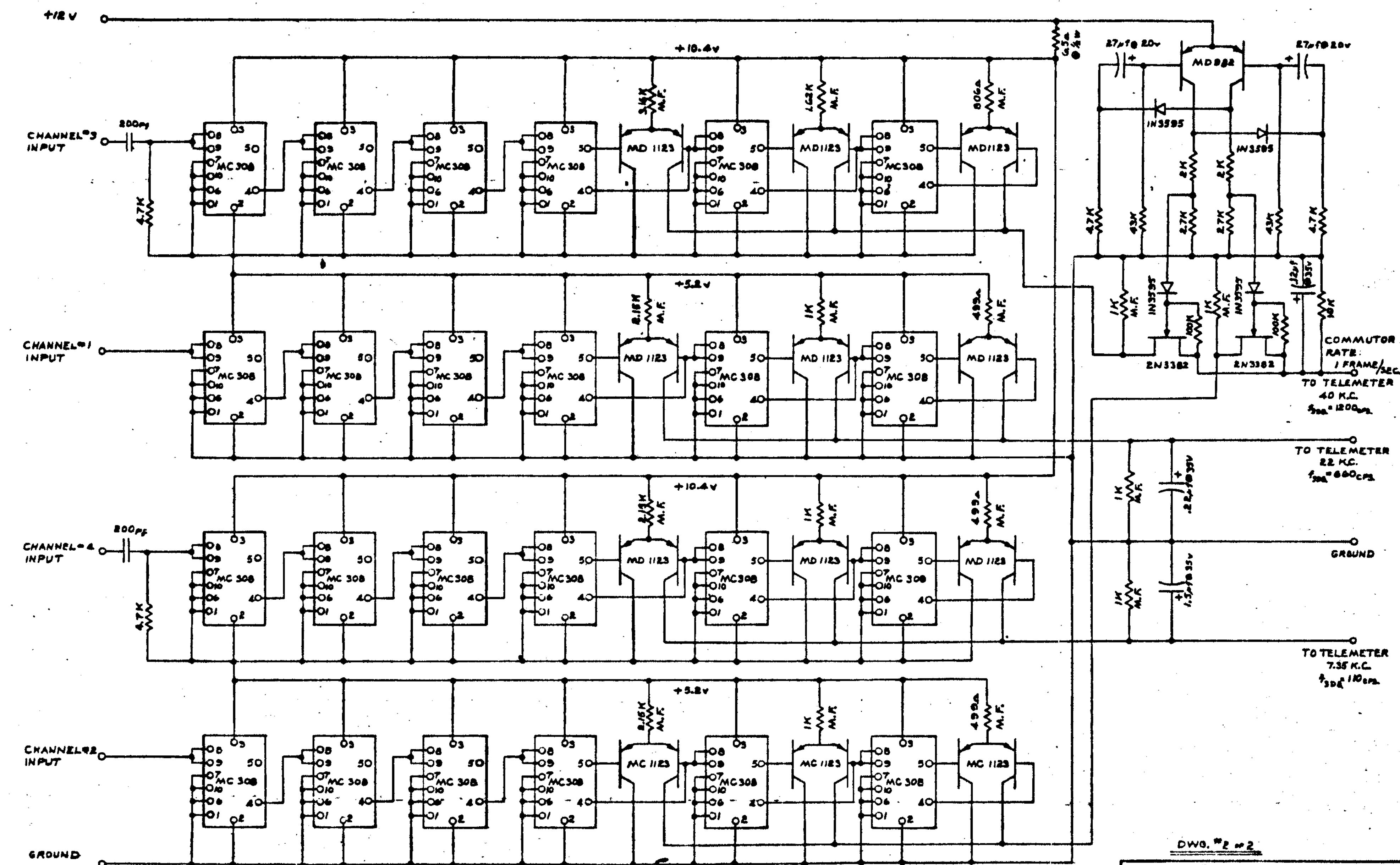
NOTE: M.F. INDICATES 1% METAL-FILM RESISTORS

VALUE OF $R_N$ IS SELECTED FOR MOST SENSITIVE ADJUSTMENT OF 2KV. OUTPUT

Sperling Corporation
WARREN, MICHIGAN

BE.CAL. HIGH VOLTAGE SUPPLY

DR. R.L.U.
DATE 3-17-66
C-5310




DWG. #2 of 2

Sparton Corporation
WARREN, MICHIGAN

AL. COUNTER SCALERS & COMMUTOR

R.L.U.
3-22-64
C-5307

NOTE: M.F. INDICATES 1%
METAL-FILM RESISTORS